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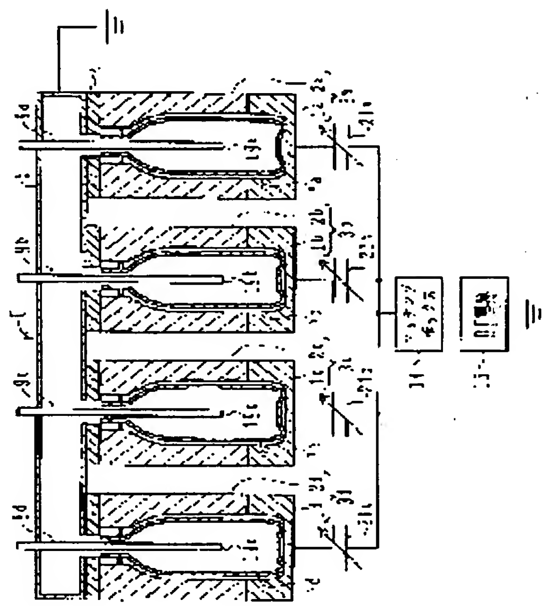
(54) SYSTEM AND METHOD FOR CVD FILM DEPOSITION

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a system and a method for CVD film deposition, in which a fixed cost is reduced and the thickness fluctuation of the thin film deposited on the inside of a container can be reduced.
SOLUTION: The CVD film deposition system is a system for depositing DLC(diamond-like carbon) film on the respective insides of a plurality of PET (polyethylene terephthalate) bottles 7a to 7d. This system has: 1st to 4th external electrodes 3a to 3d arranged in a manner to enclose the respective outsides of the PET bottles; 1st to 4th internal electrodes 9a to 9d arranged inside the PET bottles, respectively; a gas-introducing means for introducing source gas into the respective insides of the PET bottles; 1st to 4th variable condensers 21a to 21d connected to the 1st to 4th external electrodes 3a to 3d, respectively; a matching box 14 connected to the 1st to 4th variable condensers; and an RF power source 15 connected to the matching box.



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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The 1st external electrode which is CVD membrane formation equipment which forms a thin film inside each 1st and 2nd containers, and has been arranged so that the outside of the 1st container may be surrounded, The 2nd external electrode arranged so that the outside of the 2nd container may be surrounded, and the 1st internal electrode which is arranged inside the 1st external electrode and arranged inside the 1st container, The 2nd internal electrode which is arranged inside the 2nd external electrode and arranged inside the 2nd container, A gas installation means to introduce material gas into the interior of each 1st and 2nd containers, The 1st variable ceramic capacitor connected to the 1st external electrode, and the 2nd variable ceramic capacitor connected to the 2nd external electrode, CVD membrane formation equipment characterized by providing the matching box which was connected to the 1st variable ceramic capacitor, and was connected to the 2nd variable ceramic capacitor, and the RF generator connected to this matching box.
[Claim 2] It is CVD membrane formation equipment according to claim 1 which the above-mentioned matching box performs impedance matching of the 1st and 2nd whole external electrodes, and is characterized by the 1st and 2nd variable ceramic capacitors being what distributes the RF output supplied to the 1st and 2nd external electrodes by the RF generator.
[Claim 3] Two or more external electrodes which are CVD membrane formation equipment which forms a thin film inside two or more containers, and have been arranged so that the outside of each container may be surrounded, Two or more internal electrodes which are arranged inside each external electrode and arranged inside each container, A gas installation means to introduce material gas into the interior of each container, and two or more variable ceramic capacitors connected to each external electrode at juxtaposition, One matching box connected to two or more variable capacitors and the RF generator connected to this matching box are provided. The above-mentioned matching box It is CVD membrane formation equipment which performs impedance matching of two or more whole external electrodes, and is characterized by two or more above-mentioned variable ceramic capacitors being what distributes the RF output supplied to each external electrode by the RF generator.
[Claim 4] It is the CVD membrane formation approach which forms a thin film inside each 1st and 2nd containers. Arrange the 1st external electrode so that the outside of the 1st container may be surrounded, and the 2nd external electrode is arranged so that the outside of the 2nd container may be surrounded. Arrange the 1st internal electrode inside the 1st container, and the 2nd internal electrode is arranged inside the 2nd container. Connect the 1st variable ceramic capacitor to the 1st external electrode, and the 2nd variable ceramic capacitor is connected to the 2nd external electrode. The process which connects a matching box to both 1st variable ceramic capacitor and 2nd variable ceramic capacitor, and connects an RF generator to this matching box, The process which introduces material gas into the interior of each 1st and 2nd containers, and the process which supplies a RF output to each 1st and 2nd external electrodes through a matching box and the 1st and 2nd variable ceramic capacitor using the above-mentioned RF generator, The CVD membrane formation approach characterized by providing.
[Claim 5] The CVD membrane formation approach according to claim 4 that the above-mentioned matching box performs impedance matching of the 1st and 2nd whole external electrodes, and the 1st and 2nd variable ceramic capacitors are characterized by distributing the high frequency output supplied to the 1st and 2nd external electrodes by the RF generator in the process which supplies the above-mentioned high frequency output.
[Claim 6] Are the CVD membrane formation approach which forms a thin film inside two or more containers, and two or more external electrodes are arranged so that the outside of each container may be surrounded. Arrange two or more internal electrodes inside each container, and two or more variable ceramic capacitors are connected to each external electrode at juxtaposition. The process which connects two or more variable capacitors to one matching box, and connects an RF generator to this matching box, The process which

introduces material gas into the interior of each container, and the process which supplies a RF output to two or more external electrodes of each through a matching box and two or more variable ceramic capacitors using the above-mentioned RF generator, Provided and the above-mentioned matching box performs impedance matching of two or more whole external electrodes in the process which supplies the above-mentioned high frequency output. The CVD membrane formation approach characterized by two or more above-mentioned variable ceramic capacitors distributing the RF output supplied to each external electrode by the RF generator.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates to the CVD membrane formation equipment and the CVD membrane formation approach of forming a thin film inside a container with respect to CVD membrane formation equipment and the CVD membrane formation approach.
[0002]
[Description of the Prior Art] Conventional CVD (Chemical Vapor Deposition) membrane formation equipment is equipment which forms the DLC (Diamond Like Carbon) film or the Si content DLC film to the insides, such as a container, using a plasma-CVD method. The DLC film is amorphous carbon which made SP3 association between carbon the subject, and is hard carbon film which is very hard, is excellent in insulation, and has very smooth mol FOROJI with a high refractive index. Si content hydrocarbon system gas is used as material gas which forms the Si content DLC film, using hydrocarbon system gas as material gas which forms the DLC film.
[0003] Drawing 2 is the block diagram showing conventional CVD membrane formation equipment typically. This CVD membrane formation equipment has the vacuum chamber 106, and this vacuum chamber 106 consists of conductive covering devices 105, insulating members 104, and external electrodes 103. The insulating member 104 is arranged under the covering device 105, and the external electrode 103 is arranged under this insulating member 104. This external electrode 103 consists of an up electrode 102 and a lower electrode 101, and it is constituted so that the upper part of the lower electrode 101 may be attached in the lower part of the up electrode 102 free [attachment and detachment] through O ring 108. Moreover, the external electrode 103 is insulated with the covering device 105 by the insulating member 104.
[0004] Space is formed in the interior of the external electrode 103, and this space is for holding PET bottle 107 which is a plastic envelope for coating. The space in an external electrode is formed so that it may become large slightly rather than the appearance of PET bottle 107 held there. Opening connected with the space in an external electrode is prepared in the insulating member 104 and the covering device 105. Moreover, space is established in the interior of a covering device 105, and this space is connected with the space in an external electrode through the above-mentioned opening. The space in an external electrode is sealed from the outside with O ring 108 arranged between the up electrode 102 and the lower electrode 101.
[0005] The lower electrode 101 of an external electrode is connected to the impedance matching box (matching box) 114, and the matching box 114 is connected to RF generator (RF power source) 115 through the coaxial cable.
[0006] It lets the space in a covering device, and a covering device and opening of an insulating member pass from the upper part of a covering device 105, and the internal electrode 109 is fitted over the space in an external electrode. That is, the end face of an internal electrode 109 is arranged in the upper part of a covering device 105, and the tip of an internal electrode 109 is arranged inside PET bottle 107 which is the space in an external electrode and was held in the external electrode.
[0007] The internal electrode 109 has the tubing configuration which the interior becomes from hollow. Gas diffuser 109a is prepared at the tip of an internal electrode 109. The one side of piping 110 is connected to the end face of an internal electrode 109, and the other side of this piping 110 is connected to the one side of a massflow controller 119 through the vacuum bulb 116. The other side of a massflow controller 119 is connected to the material gas generation source 120 through piping 111. This material gas generation source 120 generates hydrocarbon gas etc.
[0008] The internal electrode 109 is grounded through the covering device 105. The space in a covering device is connected to the one side of piping 112, and the other side of piping 112 is made into the atmospheric-air disconnection condition through the vacuum bulb 117. Moreover, the space in a covering device is connected to the one side of piping 113, and the other side of piping 113 is connected to the vacuum pump 121 through the vacuum bulb 118.

[0009] Next, how to form the DLC film inside a container using the CVD membrane formation equipment shown in drawing 2 is explained.
[0010] First, the vacuum bulb 117 is opened and atmospheric-air disconnection of the inside of the vacuum chamber 106 is carried out. Thereby, air goes into the space in a covering device, and the space in an external electrode through piping 112, and the inside of the vacuum chamber 106 is made into atmospheric pressure. Next, the lower electrode 101 of an external electrode is removed from the up electrode 102, and PET bottle 107 is inserted and installed in the space in an up electrode from the up electrode 102 bottom. Under the present circumstances, it will be inserted by the internal electrode 109 into PET bottle 107. Next, the lower part of the up electrode 102 is equipped with the lower electrode 101, and the external electrode 103 is sealed with O ring 108.
[0011] Then, after closing the vacuum bulb 117, the vacuum bulb 118 is opened and a vacuum pump 121 is operated. The inside of a vacuum chamber including the inside of PET bottle 107 (space in an external electrode and space in a covering device) is exhausted through piping 113 by this, and the inside of an external electrode serves as a vacuum.
[0012] Next, after opening the vacuum bulb 116, hydrocarbon gas is generated in the material gas generation source 120, this hydrocarbon gas is introduced in piping 111, and the hydrocarbon gas by which control of flow was carried out with the massflow controller 119 is blown off from gas diffuser 109a through the internal electrode 109 of piping 110 and ground potential. Thereby, hydrocarbon gas is introduced in PET bottle 107. And the inside of a vacuum chamber and a PET bottle is maintained at the controlled quantity of gas flow and the pressure (for example, 0.05 - 0.5Torr extent) which was suitable for DLC membrane formation with the balance of exhaust air capacity.
[0013] Then, RF output (for example, 13.56MHz) is supplied to the external electrode 103 from RF generator (RF power source) 115 through a matching box 114. This lights the plasma between the external electrode 103 and an internal electrode 109. At this time, the matching box 114 is set by the impedance of an external electrode and an internal electrode with an inductance L and capacitance C. The hydrocarbon system plasma occurs in a PET bottle, and the DLC film is formed inside a PET bottle by this. The membrane formation time amount at this time becomes about several seconds and a short thing.
[0014] Next, RF output from the RF power source 115 is suspended, the vacuum bulb 116 is closed and supply of material gas is suspended. Then, the vacuum bulb 118 is opened and the hydrocarbon gas in the vacuum chamber 106 and PET bottle 107 is exhausted with a vacuum pump 121. Then, the vacuum bulb 118 is closed and a vacuum pump 121 is suspended. The degree of vacuum in the vacuum chamber at this time is 5x10-3Torr - 5x10-2Torr. Then, the DLC film is formed in two or more PET bottles by opening the vacuum bulb 117 and repeating the membrane formation approach which carried out atmospheric-air disconnection and mentioned above the inside of the vacuum chamber 106.
[0015]
[Problem(s) to be Solved by the Invention] By the way, in order to mass-produce the container (PET bottle) which formed the DLC film inside and to enable it to form two or more PET bottles to coincidence, two or more above-mentioned conventional CVD membrane formation equipments will be prepared. In order to arrange one matching box to one PET bottle, specifically, two or more matching boxes are needed. Moreover, the number of RF power sources is one to two or more matching boxes.
[0016] Thus, if two or more matching boxes are arranged, since a small thing also has about [300mmx300mmx400mm] magnitude, the source of the plasma will become very big and a matching box will become the failure of miniaturization of equipment. Therefore, a large location is needed for installing the CVD membrane formation equipment for mass production, and space efficiency worsens. With this, since a matching box is very expensive, equipment cost increases.
[0017] Moreover, since the matching time amount by the matching box differs delicately mutually when a matching box is installed to each external electrode which holds a PET bottle, matching time amount cannot be mutually made correctly in agreement. Although impedance matching is carried out in each matching box, specifically, a gap of about 0.1 - 1 second may arise mutually. And since the thickness of the DLC film which forms membranes inside a PET bottle is as thin as about 30nm, membrane formation time amount is good in about 3 seconds, and needs to control thickness with a further comparatively sufficient precision. For this reason, the matching time lag for about 0.1 - 1 second will influence greatly the variation in the thickness of the DLC film (especially thickness variation between PET bottles). Therefore, variation will arise in the quality of the DLC film.
[0018] This invention is made in consideration of the above situations, and the purpose is to offer the CVD membrane formation equipment and the CVD membrane formation approach of reducing the thickness variation of the thin film formed inside the container while reducing equipment cost.

[0019]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the CVD membrane formation equipment concerning this invention The 1st external electrode which is CVD membrane formation equipment which forms a thin film inside each 1st and 2nd containers, and has been arranged so that the outside of the 1st container may be surrounded, The 2nd external electrode arranged so that the outside of the 2nd container may be surrounded, and the 1st internal electrode which is arranged inside the 1st external electrode and arranged inside the 1st container, The 2nd internal electrode which is arranged inside the 2nd external electrode and arranged inside the 2nd container, A gas installation means to introduce material gas into the interior of each 1st and 2nd containers, The 1st variable ceramic capacitor connected to the 1st external electrode, and the 2nd variable ceramic capacitor connected to the 2nd external electrode, It is characterized by providing the matching box which was connected to the 1st variable ceramic capacitor, and was connected to the 2nd variable ceramic capacitor, and the RF generator connected to this matching box.
[0020] Moreover, in the CVD membrane formation equipment concerning this invention, the above-mentioned matching box performs impedance matching of the 1st and 2nd whole external electrodes, and, as for the 1st and 2nd variable ceramic capacitors, it is desirable that it is what distributes the RF output supplied to the 1st and 2nd external electrodes by the RF generator.
[0021] Two or more external electrodes which the CVD membrane formation equipment concerning this invention is CVD membrane formation equipment which forms a thin film inside two or more containers, and have been arranged so that the outside of each container may be surrounded, Two or more internal electrodes which are arranged inside each external electrode and arranged inside each container, A gas installation means to introduce material gas into the interior of each container, and two or more variable ceramic capacitors connected to each external electrode at juxtaposition, One matching box connected to two or more variable capacitors and the RF generator connected to this matching box are provided. The above-mentioned matching box Impedance matching of two or more whole external electrodes is performed, and two or more above-mentioned variable ceramic capacitors are characterized by being what distributes the RF output supplied to each external electrode by the RF generator.
[0022] According to the above-mentioned CVD membrane formation equipment, by making a matching box into one piece, the membrane formation section including the source of the plasma can be made small, and the cost of the CVD membrane formation equipment for mass production can be reduced. Moreover, it has the matching box which performs impedance matching of two or more whole external electrodes, and has two or more variable ceramic capacitors which distribute the high frequency output supplied to each external electrode. For this reason, a matching time lag can be prevented and matching time amount can be made correctly in agreement. Thereby, the variation between containers of the thickness of the thin film which formed membranes in the container can be reduced.
[0023] The CVD membrane formation approach concerning this invention is the CVD membrane formation approach which forms a thin film inside each 1st and 2nd containers. Arrange the 1st external electrode so that the outside of the 1st container may be surrounded, and the 2nd external electrode is arranged so that the outside of the 2nd container may be surrounded. Arrange the 1st internal electrode inside the 1st container, and the 2nd internal electrode is arranged inside the 2nd container. Connect the 1st variable ceramic capacitor to the 1st external electrode, and the 2nd variable ceramic capacitor is connected to the 2nd external electrode. The process which connects a matching box to both 1st variable ceramic capacitor and 2nd variable ceramic capacitor, and connects an RF generator to this matching box, It is characterized by providing the process which supplies a RF output through a matching box and the 1st and 2nd variable ceramic capacitor at each 1st and 2nd external electrodes using the process which introduces material gas into the interior of each 1st and 2nd containers, and the above-mentioned RF generator.
[0024] Moreover, in the CVD membrane formation approach concerning this invention, it is desirable that the above-mentioned matching box performs impedance matching of the 1st and 2nd whole external electrodes, and the 1st and 2nd variable ceramic capacitors distribute the high frequency output supplied to the 1st and 2nd external electrodes by the RF generator at the process which supplies the above-mentioned high frequency output.
[0025] The CVD membrane formation approach concerning this invention is the CVD membrane formation approach which forms a thin film inside two or more containers. Arrange two or more external electrodes so that the outside of each container may be surrounded, and two or more internal electrodes are arranged inside each container. The process which connects two or more variable ceramic capacitors to juxtaposition at each external electrode, connects two or more variable capacitors to one matching box, and connects an RF generator to this matching box, The process which introduces material gas into the interior of each container, and the process which supplies a RF output to two or more external electrodes of each through a matching box

and two or more variable ceramic capacitors using the above-mentioned RF generator, It provides, the above-mentioned matching box performs impedance matching of two or more whole external electrodes in the process which supplies the above-mentioned high frequency output, and two or more above-mentioned variable ceramic capacitors are characterized by distributing the high frequency output supplied to each external electrode by the RF generator.

[0026]

[Embodiment of the Invention] Hereafter, the gestalt of 1 operation of this invention is explained with reference to a drawing. The CVD membrane formation equipment by the gestalt of operation of this invention is equipment which forms the DLC film or the Si content DLC film to the insides, such as a container, using a plasma-CVD method.

[0027] Drawing 1 is the block diagram showing typically the CVD membrane formation equipment by the gestalt of operation of this invention. This CVD membrane formation equipment has the vacuum chamber 6, and this vacuum chamber 6 consists of the conductive covering device 5, insulating member 4 and 1st thru/or 4th external electrode 3a-3d. The insulating member 4 is arranged under the covering device 5, and the 1st thru/or 4th external electrode 3a-3d is arranged under this insulating member 4 at juxtaposition.

[0028] 1st external electrode 3a consists of the 1st up electrode 2a and the 1st lower electrode 1a, and it is constituted so that the upper part of 1st lower electrode 1a may be attached in the lower part of 1st up electrode 2a free [attachment and detachment] through an O ring (not shown). Similarly, 2nd external electrode 3b consists of the 2nd up electrode 2b and the 2nd lower electrode 1b, and it is constituted so that the upper part of 2nd lower electrode 1b may be attached in the lower part of 2nd up electrode 2b free [attachment and detachment] through an O ring (not shown). 3rd external electrode 3c consists of the 3rd up electrode 2c and the 3rd lower electrode 1c, and it is constituted so that the upper part of 3rd lower electrode 1c may be attached in the lower part of 3rd up electrode 2c free [attachment and detachment] through an O ring (not shown). 3d of 4th external electrode consists of 2d of the 4th up electrode, and 1d of the 4th lower electrode, and it is constituted so that the upper part of 1d of 4th lower electrode may be attached in the lower part of 2d of 4th up electrode free [attachment and detachment] through an O ring (not shown). Moreover, the 1st thru/or 4th external electrode 3a-3d is insulated with the covering device 5 by the insulating member 4.

[0029] the 1st thru/or 4th external electrode 3 -- a-3d of space is formed in each interior, and such space is for holding PET bottles 7a-7d which are the plastic envelopes for coating. The space in an external electrode is formed so that it may become large slightly rather than a PET bottles [which are held there / 7a-7d] appearance. Four openings connected with the space inside each 1st thru/or 4th external electrode are prepared in the insulating member 4 and the covering device 5. Moreover, space is established in the interior of a covering device 5, and this space is connected with the space in the 1st thru/or 4th external electrode through the above-mentioned opening. The space in the 1st thru/or 4th external electrode is sealed from the outside with the O ring arranged between the 1st 4th up electrodea [2]-2d and the 1st thru/or 4th lower electrode 1a-1d.

[0030] the 1st thru/or 4th external electrode 3a-3d -- respectively -- being alike -- the 1st thru/or the 4th variable ceramic capacitor 21a-21d are connected. Namely, 1st variable ceramic capacitor 21a is connected to 1st lower electrode 1a in the 1st external electrode. 2nd variable ceramic capacitor 21b is connected to 2nd lower electrode 1b in 2nd external electrode 3b. 3rd variable ceramic capacitor 21c is connected to 3rd lower electrode 1c in 3rd external electrode 3c, and the 21d of the 4th variable ceramic capacitor is connected to 1d of 4th lower electrode in 3d of 4th external electrode.

[0031] The 1st thru/or the 4th variable ceramic capacitor 21a-21d are connected to one impedance matching box (matching box) 14, and the matching box 14 is connected to RF generator (RF power source) 15 through the coaxial cable.

[0032] A matching box 14 performs impedance matching of the 1st thru/or 4th whole external electrode. the 1st thru/or the 4th variable ceramic capacitor 21 -- a-21d of each is for distributing RF output supplied to the 1st thru/or 4th external electrode 3a-3d, controlling RF output, and preventing a matching time lag according to the RF power source 15. In addition, as for variable ceramic capacitors 21a-21d, it is desirable to set up manually.

[0033] It lets the space in a covering device, and a covering device and opening of an insulating member 4 pass from the upper part of a covering device 5, and the 1st thru/or the 4th internal electrode 9a-9d are fitted over the space in the 1st thru/or 4th external electrode. namely, the 1st thru/or the 4th internal electrode 9 -- a-9d of each end face is arranged in the upper part of a covering device 5 -- having -- the tip of the 1st thru/or each 4th internal electrode -- the 1st thru/or 4th external electrode 3 -- it is arranged to the PET bottles [which are each building envelope a-3d, and were held in the external electrode / 7a-7d] interior.

[0034] the 1st thru/or the 4th internal electrode 9 -- each has a-9d of tubing configurations which the interior becomes from hollow. The gas diffusers 19a-19d are formed at the tip of the 1st thru/or each 4th internal

electrode. The one side of piping (not shown) is connected to the end face of the 1st thru/or each 4th internal electrode, and the other side of this piping is connected to the one side of a massflow controller (not shown) through the vacuum bulb (not shown). The other side of a massflow controller is connected to the material gas generation source (not shown) through piping (not shown). This material gas generation source generates hydrocarbon gas etc. In addition, arrangement of piping, a vacuum bulb, a massflow controller, and each material gas generation source is the same as that of conventional CVD membrane formation equipment almost.

[0035] The 1st thru/or the 4th internal electrode 9a-9d are grounded through the covering device 5. Moreover, the space in a covering device is connected to the one side of piping (not shown), and the other side of piping is made into the atmospheric-air disconnection condition through the vacuum bulb (not shown). Moreover, the space in a covering device is connected to the one side of piping (not shown), and the other side of piping is connected to the vacuum pump (not shown) through the vacuum bulb (not shown). In addition, arrangement of piping, a vacuum bulb, and each vacuum pump is the same as that of conventional CVD membrane formation equipment almost.

[0036] Next, how to form the DLC film inside a container using the CVD membrane formation equipment shown in drawing 1 is explained.

[0037] First, a vacuum bulb is opened and atmospheric-air disconnection of the inside of the vacuum chamber 6 is carried out. Thereby, air goes into the space in a covering device, and the space in an external electrode through piping, and the inside of the vacuum chamber 6 is made into atmospheric pressure. Next, the 1st thru/or 4th lower electrode 1a-1d in the 1st thru/or 4th external electrode is removed from the 1st thru/or 4th up electrode 2a-2d, and PET bottles 7a-7d are inserted and installed in the space in an up electrode from the those up electrodes [2a-2d] bottom. under the present circumstances, the 1st thru/or the 4th internal electrode 9 -- it will be inserted into each PET bottle 7a-7d by a-9d of each. next, the 1st thru/or 4th lower electrode 1a-1d -- each -- the 1st thru/or 4th up electrode 2 -- each lower part -- equipping -- the 1st thru/or 4th external electrode 3 -- a-3d of each building envelope is sealed with an O ring.

[0038] Then, after closing a vacuum bulb, other vacuum bulbs are opened and a vacuum pump is operated. The inside (the building envelope of each 1st thru/or 4th external electrode and space in a covering device) of the vacuum chamber 6 including the PET bottles [7a-7d] interior is exhausted through piping by this, and the building envelope of each 1st thru/or 4th external electrode serves as a vacuum.

[0039] Next, after opening a vacuum bulb, hydrocarbon gas is generated in a material gas generation source, this hydrocarbon gas is introduced in piping, and the hydrocarbon gas by which control of flow was carried out with the massflow controller is blown off from the gas diffusers 19a-19d through the 1st thru/or the 4th internal electrode 9a-9d of piping and ground potential. Thereby, hydrocarbon gas is introduced in each PET bottle. And the inside of a vacuum chamber and a PET bottle is maintained at the controlled quantity of gas flow and the pressure (for example, 0.05 - 0.5Torr extent) which was suitable for DLC membrane formation with the balance of exhaust air capacity.

[0040] Then, RF output (for example, 13.56MHz) is supplied to the 1st thru/or 4th external electrode 3a-3d from RF generator (RF power source) 15 through one matching box 14 and the 1st thru/or the 4th variable ceramic capacitor 21a-21d. Under the present circumstances, a matching box 14 performs impedance matching of the 1st thru/or 4th whole external electrode, RF output supplied to the 1st thru/or 4th external electrode by the 1st thru/or the 4th variable ceramic capacitor is distributed, and RF output is controlled.

[0041] Thus, by supplying RF output to the 1st thru/or 4th external electrode, the plasma is lit between the 1st each 4th external electrode and the 1st thru/or each 4th internal electrode. At this time, the matching box 14 is set by the impedance of an external electrode and an internal electrode with an inductance L and capacitance C. The hydrocarbon system plasma occurs in a PET bottle, and the DLC film is formed inside a PET bottle by this. The membrane formation time amount at this time becomes about several seconds and a short thing.

[0042] Next, RF output from the RF power source 15 is suspended, a vacuum bulb is closed and supply of material gas is suspended. Then, other vacuum bulbs are opened and the vacuum chamber 6 and the hydrocarbon gas of the PET bottles [7a-7d] interior are exhausted with a vacuum pump. Then, a vacuum bulb is closed and a vacuum pump is suspended. The degree of vacuum in the vacuum chamber at this time is 5x10-3Torr [for example,] - 5x10-2Torr. Then, the PET bottle with which the DLC film was formed inside can be mass-produced by opening a vacuum bulb and repeating the membrane formation approach which carried out atmospheric-air disconnection and mentioned above the inside of the vacuum chamber 6.

[0043] According to the gestalt of the above-mentioned implementation, the matching box 14 which performs impedance matching of the 1st thru/or 4th whole external electrode has been arranged, and the 1st thru/or the 4th variable ceramic capacitor 21a-21d which performs the distribution and control of RF output which are supplied to each external electrode are arranged. For this reason, a matching time lag can be prevented and matching time amount can be made correctly in agreement. If the processing time which forms the DLC film can

be shortened and it puts in another way in a PET bottle by this, the rate of membrane formation processing can be improved. Therefore, it becomes easy for the interior to mass-produce the PET bottle which formed the DLC film, and the cost at the time of mass production can be reduced.

[0044] Moreover, the variation between PET bottles of the thickness of the DLC film which formed membranes in the PET bottle can be reduced by preventing a matching time lag. Therefore, the thickness of the DLC film between PET bottles can be controlled with a sufficient precision, and the quality variation of the DLC film can be controlled.

[0045] Moreover, if conventional CVD membrane formation equipment is used, with the gestalt of this operation, the matching box 14 is made into one piece to arranging the matching box of the same number as an external electrode. For this reason, the source of the plasma of a number bookstand can be made small, and miniaturization of equipment can be attained. Therefore, space-saving-ization of the CVD membrane formation equipment for mass production can be attained. With this, equipment cost can be reduced by making a matching box into one piece compared with conventional equipment. Cost can be set to one fourth in the number of matching boxes.

[0046] In addition, it is possible for this invention not to be limited to the gestalt of the above-mentioned implementation, but to change variously, and to carry out. For example, it is also possible for it not to be restricted to the generation source of hydrocarbon gas, but to use various generation sources as a material gas generation source, for example, it is also possible to use Si content hydrocarbon system gas etc.

[0047] Moreover, although the PET bottle of a bevel use is used for the interior with the gestalt of this operation as a container which forms a thin film, it is also possible to use the container used for other applications.

[0048] Moreover, although the DLC film or the Si content DLC film is mentioned with the gestalt of this operation as a thin film which forms membranes with CVD membrane formation equipment, in case other thin films are formed in a container, it is also possible to use the above-mentioned CVD membrane formation equipment.

[0049] Moreover, although this invention is applied to the CVD membrane formation equipment which has four external electrodes with the gestalt of this operation, if a variable ceramic capacitor is arranged for every one external electrode, it is also possible to apply this invention to the CVD membrane formation equipment which has two pieces, three pieces, or five external electrodes or more.

[0050]

[Effect of the Invention] As explained above, while reducing equipment cost according to this invention, the CVD membrane formation equipment and the CVD membrane formation approach of reducing the thickness variation of the thin film formed inside the container can be offered.

[Translation done.]

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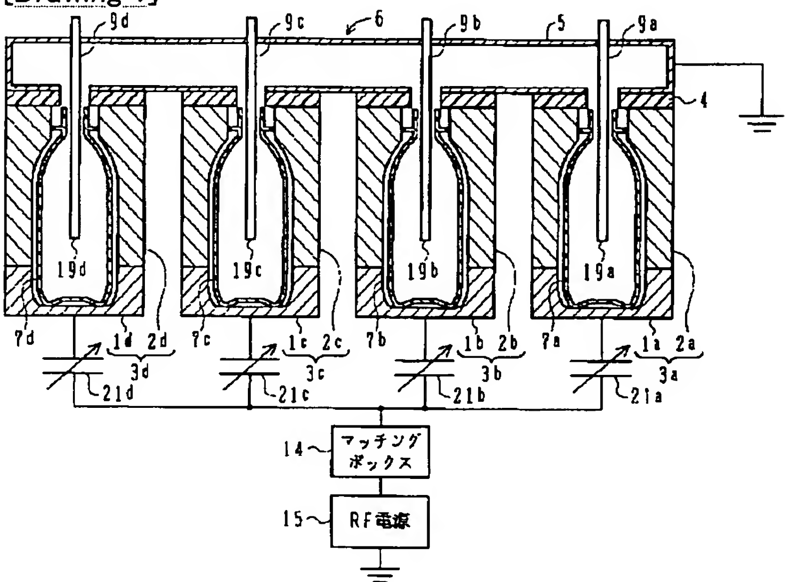
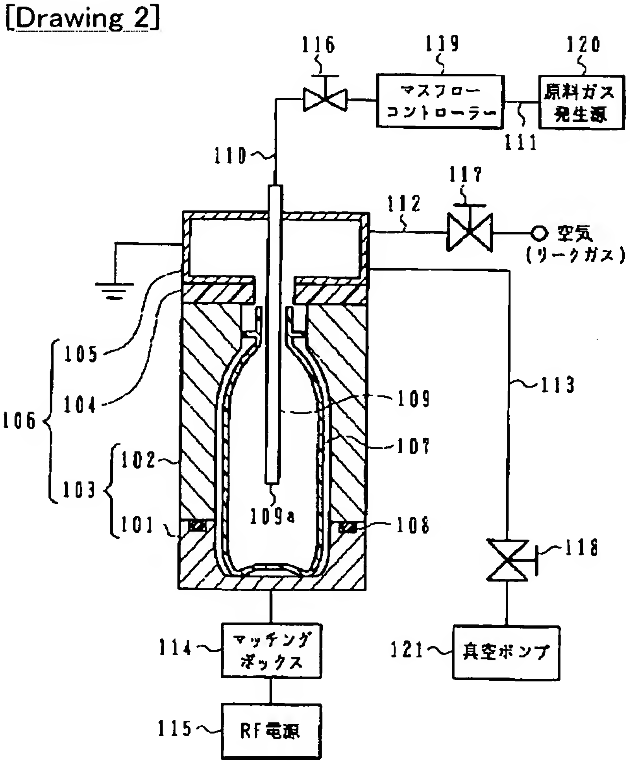
DRAWINGS

[Drawing 1]



[Drawing 2]



[Translation done.]